PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

GILL JENNINGS & EVERY
Boradgate Hosue
7 Eldon Street
London EC2M 7LH
ROYAUME-UNI

Date of mailing (day/month/year)
08 November 2000 (08.11.00)

Applicant's or agent's file reference
SK/P10443PC

IMPORTANT NOTIFICATION

International application No.
PCT/GB00/00868

International filing date (day/month/year)
09 March 2000 (09.03.00)

1. The following indications appeared on record concerning:

[ ] the applicant [ ] the inventor [X] the agent [ ] the common representative

Name and Address

McCALLUM, William, Potter
Cruikshank & Fairweather
19 Royal Exchange Square
Glasgow G1 3AE
United Kingdom

State of Nationality:
State of Residence:
Telephone No.: 0141 221 5767
Facsimile No.: 0141 221 7739
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[X] the person [ ] the name [ ] the address [ ] the nationality [ ] the residence

Name and Address

GILL JENNINGS & EVERY
Boradgate Hosue
7 Eldon Street
London EC2M 7LH
United Kingdom

State of Nationality:
State of Residence:
Telephone No.: 44 20 7377 1377
Facsimile No.: 44 20 7377 1310
Teleprinter No.:

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[X] the designated Offices concerned
[ ] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

R. Raissi

Telephone No.: (41-22) 338.83.38

Copy for the Elected Office (EO/US) PCT/GB00/00868

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

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NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

GILL JENNINGS & EVERY
Boradgate Hosue
7 Eldon Street
London EC2M 7LH
ROYAUME-UNI

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27 août 2001 (27.08.01)

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IMPORTANT NOTIFICATION

International application No.
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International filing date (day/month/year)
09 mars 2000 (09.03.00)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address
DUNCAN, Ian, James
2 Neilson Court
Blackburn
Midlothian
United Kingdom

State of Nationality: GB
State of Residence: GB
Telephone No.:
Facsimile No.:
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[X] the person [ ] the name [ ] the address [ ] the nationality [ ] the residence

Name and Address
FUTURETECH TECHNOLOGIES LIMITED
11 Linden Gardens
Tunbridge Wells
Kent TN2 5QU
United Kingdom

State of Nationality: GB
State of Residence: GB
Telephone No.:
Facsimile No.:
Teleprinter No.:

3. Further observations, if necessary:
DUNCAN, Ian, James remains applicant for the US only.

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

Authorized officer
R. Raissi
Telephone No.: (41-22) 338.83.38

NR

PATENT COOPERATION TREATY

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NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

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US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 06 December 2000 (06.12.00)	
International application No. PCT/GB00/00868	**Applicant's or agent's file reference** SK/P10443PC
International filing date (day/month/year) 09 March 2000 (09.03.00)	**Priority date** (day/month/year) 09 March 1999 (09.03.99)
Applicant DUNCAN, Ian, James	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

09 October 2000 (09.10.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Lazar Joseph Panakal
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

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14.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
MJB06715WO		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB 00/ 00868	09/03/2000	09/03/1999
International Patent Classification (IPC) or national classification and IPC		
B63B1/16		
Applicant		
DUNCAN, Ian James		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   [X] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consists of a total of 5 sheets.

3. This report contains indications relating to the following items:

   - I [X] Basis of the report
   - II [ ] Priority
   - III [ ] Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV [ ] Lack of unity of invention
   - V [X] Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI [ ] Certain documents cited
   - VII [ ] Certain defects in the international application
   - VIII [X] Certain observations on the international application

Date of submission of the demand	Date of completion of this report
09/10/2000	04.05.01
Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. (+49-89) 2399-0, Tx: 523656 epmu d Fax: (+49-89) 2399-4465	A. M. BRUMER

I. Basis of the report

1. This report has been drawn up on the basis of *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.)*

☐ the international application as originally filed

☒	the description, pages	1, 2, 4, 5, 7 - 17	, as originally filed	
	pages		, filed with the demand	
	pages	3, 6	, filed with the letter of	19.03.01
☒	the claims, Nos.		, as originally filed	
	Nos.		, as amended under Article 19	
	Nos.		, filed with the demand	
	Nos.	1 - 26	, filed with the letter of	19.03.01
☒	the drawings, sheets / fig.	1/9 - 9/9	, as originally filed	
	sheets / fig.		, filed with the demand	
	sheets / fig.		, filed with the letter of	

2. The amendments have resulted in the cancellation of:

☐ the description, pages:

☐ the claims, Nos.

☐ the drawings, sheets / fig.

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2 (c)).

4. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inv ntiv step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Claims	1 - 26	YES
	Claims		NO
Inventive Step	Claims	1 - 26	YES
	Claims		NO
Industrial Applicability	Claims	1 - 26	YES
	Claims		NO

2. Citations and Explanations

1. D1 (US-A-4 774 902) is reflecting the nearest prior art and discloses the features of the first part of independent Claim 1.

   The object of improving the performance of a high speed hull is achieved by the features of the characterizing part of claim 1

   There is no hint in the available prior art documents as to the limitation of the aspect later proposed in Claim 1.

2. Independent claim 24 is concerned with a water craft incorporating a hull as per the preceding claims.

3. The appended claims refer to preferred embodiments of the invention.

VIII. Certain obs rvations on the int rnati nal application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

1. Claim 7 is not clear as to how the side wing portions are to be designed, since the description mentions only the design according to Claim 8, whereas other configurations such as for example skids, do not sem to be supported by the description.

2. Claim 10 is directed to a hull and not to a water craft, and therefore the mention of propellers attached to the transom of said hull does not seem to be appropriate.

3. The back reference of Claim 17 to Claim 21 is definitely incorrect and should be corrected.

4. The reference to a parallel UK application on page 5 without indicating a publication number is improper. Its introduction by reference makes no sense. As a general matter introduction by reference is misleading since it is not clear which features are to be considered.

It is an aim of the present invention to avoid or minimise one or more of the foregoing disadvantages.

According to a first aspect of the invention there is provided a hull for a water craft, wherein the centre of gravity of the hull is substantially vertically aligned with the centre of hydrodynamic lift of a lifting surface of the hull, both at lift-off speed and at design speed; characterised in that the aspect ratio of the wetted hull at design speed is in the range of 2.5 to 5.0.

The centre of gravity and centre of hydrodynamic lift are preferably substantially aligned at all hull speeds between lift-off and design speed and above, and may also be substantially vertically aligned at hull speeds below lift-off (i.e. displacement speeds).

Such a hull has the advantage of improved hydrodynamic stability and generally does not require trim devices. The aspect ratio of the hull at lift-off speed is preferably in the range of 1.5 to 2.5.

Preferably, a leading edge of the wetted area of the hull at design speed is generally transverse to the direction of forward movement of the hull, along at least a portion, preferably a substantial portion, of its length, whereby a spray sheet which may be created by the hull, in use thereof, is projected generally forwards such that the craft rides over the spray sheet. This has the advantage that entrained air in the spray tend to reduce skin friction when the craft rides forward over the spray.

The hull is preferably formed and arranged such that, if a craft incorporating the hull pitches such that the bow of the

The cambe urfaces of the hull of the invention l to much reduced lateral drag and thus less tend ncy for the hull to "dig in" while turning.

The hull may further include a fin or keel which may be formed and arranged so that the centre of lateral resistance thereof is substantially vertically aligned with the centre of gravity of the hull. The fin may be retractable to reduce drag when not required.

Preferred embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings in which:

FIG. 1 is a side elevation of a planing hull of known art operating at sub-planing speed;

FIG. 2 shows the hull of FIG. 1 operating at its design speed and attitude;

FIG. 3 is a plan elevation of an improved hull of known art;

FIG. 4 is a side elevation of the hull of FIG.3;

Fig. 5 is an isometric view from above of a hull according to the present invention;

FIG. 6 is a side elevation of the hull of FIG. 5;

FIG. 6A is a schematic side view of a portion of the hull of FIG. 6, showing a spray sheet created by the hull;

FIG. 7 is a plan elevation of the hull of FIGS. 5 and 6, showing lifting surfaces thereof, and with a rear flap and propellers omitted for clarity;

FIG. 8 shows the hull of FIG. 6 in plan elevation;

FIG. 9 shows the hull of FIG. 6 in rear elevation;

FIG. 10 is an isometric view of the underside of the hull of FIG. 6;

FIG. 11 is a schematic side view of an embodiment of the invention incorporating a chine hull and fold-up wings;

CLAIMS

1. A hull (1) for a water craft, wherein the centre of gravity (C_g) of the hull is substantially vertically aligned with the centre of hydrodynamic lift (C_p) of a lifting surface of the hull, both at lift-off speed and at design speed; characterised in that the aspect ratio (S^2/A) of the wetted hull (1) at design speed is in the range of 2.5 to 5.0.

2. A hull according to claim 1, wherein the centre of gravity (C_g) and centre of hydrodynamic lift (C_p) are substantially vertically aligned at all hull speeds between lift-off and design speed and above.

3. A hull according to claim 1 or claim 2, wherein the centre of gravity (C_g) and centre of hydrodynamic lift are also substantially vertically aligned at hull speeds below liftoff.

4. A hull according to any one of claims 1 to 3, wherein the aspect ratio (S^2/A) of the hull (1) at lift-off speed is in the range of 1.5 to 2.5.

5. A hull according to any preceding claim, wherein a leading edge (28) of the wetted area of the hull (1) at design speed is generally transverse to the direction of forward movement of the hull along at least a portion (12) of its length, whereby a spray sheet (26) which may be created by the hull, in use thereof, is projected generally forwards such that the craft rides over the spray sheet.

6. A hull according to claim 5, wherein the leading edge (28) of the wetted area of the hull at design speed is generally transverse to the direction of forward movement of the hull along at least a substantial portion (12) of its length.

7. A hull according to any preceding claim, wherein the hull (1) is of generally delta-shape in plan view, comprising a central portion (1a) and two side wing portions (1b, 1c).

8. A hull according to claim 7, wherein each side wing portion (1b, 1c) extends laterally and rearwardly from the central portion (1a) so as to define an open area (5) therebetween, adjacent a transom (3) of the central portion of the hull.

9. A hull according to claim 8, wherein the hull (1) additionally includes a cover portion for covering this open area.

10. A hull according to claim 8 or claim 9, wherein the hull is provided with two propellers (22, 22a) attached to the transom (3) of the central portion of the hull.

11. A hull according to any of claims 8 to 10, further including an abruptly downswept trailing edge portion.

12. A hull according to claim 11, wherein said trailing edge portion is integrally formed in the hull.

13. A hull according to claim 11, wherein said trailing edge portion is provided in the form of a rear flap means (20) affixed to a trailing end of the hull, the flap means projecting generally downwardly from the hull at an angle of greater than 45 degrees to the free water surface (2_1) , at design conditions.

14. A hull according to claim 13, wherein the flap means projects generally downwardly from the hull at an angle of substantially 90 degrees.

15. A hull according to claim 13 or claim 14, wherein said flap means extends over the full width of the transom of the central portion of the hull and also extends across the full length of inner (6b, 6c) and trailing (7b, 7c) edges of each side wing portion (lb. lc) defining the open area (5) at the rear of the hull (1).

16. A hull according to any of claims 13 to 15, wherein the chord of the flap means is variable.

17. A hull according to claim 21, wherein the chord of the flap means at the transom (3) of the central portion (1a) of the hull is independently variable of the chord of the flap means at the inner and trailing edges of the wing portions.

18. A hull according to any of claims 7 to 17, wherein the central portion (1a) of the hull includes a nose portion (1d) which comprises a forward surface extending rearwardly and downwardly from a nose of the hull towards a trailing end portion of the central

portion of the hull, a[illegible]ghtly cambered in longitudinal sectio[illegible]ereof such that the angle (of said forward surface relative to the water surface, in uses of th hull, is progressively reduced along the length of said nose portion towards said trailing end portion of the hull.

19. A hull according to any of claims 7 to 18, wherein each side wing portion (1b.1c) is lightly cambered in transverse cross-section thereof such that the angle of an underside (50b,50c) of each side wing portion relative to the water surface is progressively reduced from a tip (10b,10c) of the wing portion, along the transverse width of the wing portion, towards the central portion (1a) of the hull (1).

20. A hull according to claim 19, wherein each side wing portion (1b,1c) is also similarly lightly cambered in longitudinal section thereof.

21. A hull according to any of claims 7 to 20, wherein each side wing portion (1b,1c) has an underside portion which is inclined to an underside (36) of the central portion (1a) of the hull at an angle (A) which is in the range of 2 to 10 degrees.

22. A hull according to any preceding claim, further including a keel (50) extending downwardly form an underside of the hull and which is formed and arranged so that the centre of lateral resistance of the keel (50) is substantially vertically aligned with the centre of gravity (C_g) of the hull.

23. A hull according to claim 22, wherein said keel (50) is retractable.

24. A water craft incorporating a hull (1) according to any preceding claim.

25. A water craft according to claim 24, wherein the hull (1) is formed and arranged such that, if the craft pitches such that the bow (32) of the craft raises, the hydrodynamic centre of lift (C_p) of a lifting surface of the hull moves sharply rearwards as the stem of the craft becomes immersed.

26. A water craft according to claim 25, wherein the hull (1) is also formed and arranged such that if the craft pitches such that the bow (32) of the craft lowers, the hydrodynamic centre of lift (C_p) of said lifting surface of the hull moves sharply forwards.

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(71)(72) Applicant and Inventor: DUNCAN, Ian, James [GB/GB]; 2 Neilson Court, Blackburn, Midlothian EH47 7NA (GB).

(74) Agents: McCALLUM, William, Potter et al.; Cruikshank & Fairweather, 19 Royal Exchange Square, Glasgow G1 3AE (GB).

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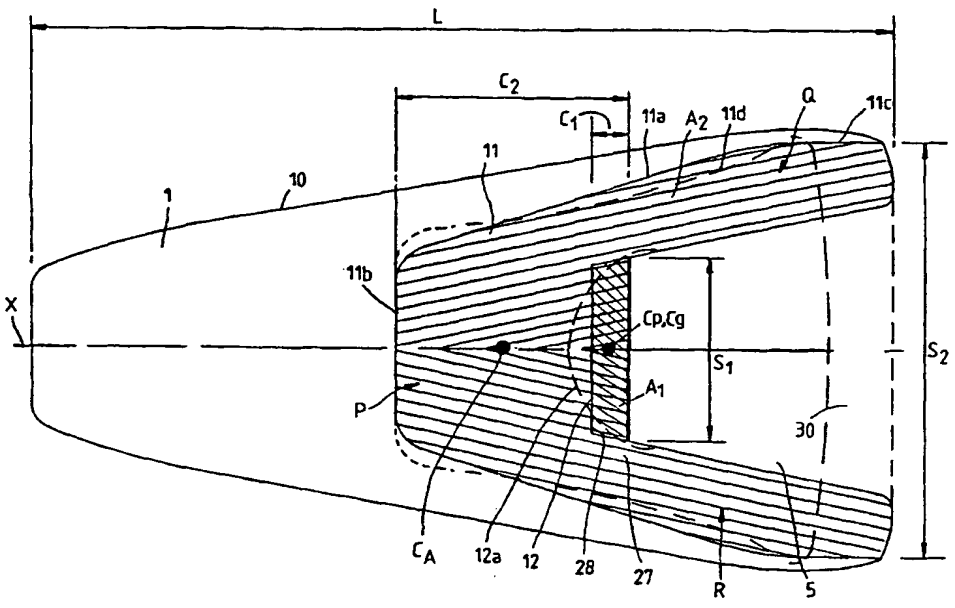

(57) Abstract

The application relates to water craft hulls having improved hydrodynamic stability. A hull (1) is claimed in which the centre of gravity (C_g) is substantially vertically aligned with the centre of hydrodynamic lift (C_p) of a lifting surface of the hull, both at lift–off speed and at design speed, and preferably also at speeds below lift–off, and at all speeds between lift–off and design speed and above. A hull having a relatively high aspect ratio ($S1^2/A1$) at design speed, and preferably also at lift–off speed, is also disclosed. In the preferred embodiment, the hull is generally delta–shaped in plan view.

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HULL FOR HIGH SPEED WATER CRAFT

The present invention relates to high speed planing boats and, in particular, hulls which reduce hydrodynamic drag and improve hydrodynamic stability in such boats.

Planing hulls of known art suffer from a number of draw-backs including:-

1) The centre of lift for the incidence required for minimum drag varies widely with speed. A number of ways of dealing with this problem are well established and include the fitting of variable trim tabs at the transom and trimming the propeller to provide a balancing moment. These methods have a negative influence on performance.

2) At high speeds hulls of known art are prone to longitudinal instability. At high angles of incidence most such hull types are prone to porpoising whilst such hulls, particularly those arranged with a convex entry to a generally flat rear section, are prone to instability at low angles of incidence.

3) Vee hulls of known art have lifting surfaces which operate at poor ratios of lift to drag due to a number of causes. Such hulls tend to have a substantially delta form of low aspect ratio, $span^2/area$, where the span is the transverse width of the lifting surface, and the area is the area of the lifting surface. This results in considerable tip losses. Additionally, the Froude number ($Vs/\sqrt{(g \times L)}$), where 'L' is the longitudinal length of the surface, is low due to the high value of 'L' resulting in high spray drag and wave making drag. Furthermore, the spray sheet is projected laterally due to the Vee entry angle such that it is not generally entrained below the lifting surface.

4) At high speeds the hydrodynamic centre of lift is optimally arranged close to the transom whereas the aerodynamic lift centre is usually situated close to the centre of the craft and at some considerable distance forward of the hydrodynamic lift centre. This results in aerodynamic instability with the well known consequence that such craft have a marked tendency

to flip over rearwards in waves or if running at an excessive trim angle.

5) Many hulls of known art have a tendency to 'dig-in' whilst turning at high speeds - particularly in wave conditions. This can cause the lift force vector to pass below the centre of gravity and thereby cause the craft to flip sideways. This is particularly the case for deep Vee hulls which are notoriously difficult to pilot at speed under such conditions.

6) In a steady turn the centripetal force, together with the side force exerted by the propulsor or rudder which is required to turn the craft, has to be balanced by an equal force generated by the hull. Vee type planing hulls are not well adapted to provide such side force and can in fact cause considerable drag and the resulting flow over the hull can cause disturbed entry conditions to the propulsor, resulting in loss of thrust.

In recent years a number of improvements to planing hulls have been proposed to reduce the variation of the position of the centre of lift with speed and to improve hydrodynamic stability. Examples of such improvements are US4903626 (Haines), US5111767 (Haines) and US5685253 (Alexander) which all show a vented cut-out in the rear transom such that the hydrodynamic centre of lift of the design lifting surface is moved forward. This has the effect of allowing the hydrodynamic centre of lift to be vertically aligned with the centre of gravity at the design speed such that the requirement for a downward trim force is negated at design speed. Furthermore the resulting longitudinally extended lifting surface aides longitudinal stability and helps reduce the onset of porpoising. Hulls of this type still require a positive (upward) trimming force to be applied at the stern at lift-off speed (sometimes also referred to as planing speed) to overcome the moment due to the hydrodynamic lift centre being forward of the centre of gravity, resulting in a lifting surface at lift-off which has two narrow rearward-extending legs which result in considerable hydrodynamic drag.

It is an aim of the present invention to avoid or minimise one or more of the foregoing disadvantages.

According to a first aspect of the invention there is provided a hull for a water craft, wherein the centre of gravity of the hull is substantially vertically aligned with the centre of hydrodynamic lift of a lifting surface of the hull, both at lift-off speed and at design speed. The centre of gravity and centre of hydrodynamic lift are preferably substantially aligned at all hull speeds between lift-off and design speed and above, and may also be substantially vertically aligned at hull speeds below lift-off (i.e. displacement speeds).

Such a hull has the advantage of improved hydrodynamic stability and generally does not require trim devices.

According to another aspect of the invention there is provided a hull for a water craft, wherein the hull has a relatively high aspect ratio at design speed, and preferably also at lift-off speed. The aspect ratio of the hull at design speed is preferably in the range of 2.5 to 5.0. The aspect ratio of the hull at lift-off speed is preferably in the range of 1.5 to 2.5.

Preferably, a leading edge of the wetted area of the hull at design speed is generally transverse to the direction of forward movement of the hull, along at least a portion, preferably a substantial portion, of its length, whereby a spray sheet which may be created by the hull, in use thereof, is projected generally forwards such that the craft rides over the spray sheet. This has the advantage that entrained air in the spray tend to reduce skin friction when the craft rides forward over the spray.

The hull is preferably formed and arranged such that, if a craft incorporating the hull pitches such that the bow of the

craft raises, the hydrodynamic centre of lift (C_p) moves sharply rearwards as the stern of the craft becomes immersed. Since the centre of gravity (C_g) of the hull is then forward of the hydrodynamic centre of lift (C_p), the weight of the craft will apply a restoring moment to the craft which stabilizes the craft. Advantageously, the hull may also be formed and arranged such that, if a craft incorporating the hull pitches such that the bow of the craft lowers, the hydrodynamic centre of lift (C_p) moves sharply forwards. Since the centre of gravity (C_g) of the hull is then rearward of the hydrodynamic centre of lift (C_p), the weight of the craft will again apply a restoring moment to the craft. These features tend to reduce longitudinal instability and porpoising of the hull.

The hull is preferably of generally delta-shape in plan view, comprising a central portion and two side wing portions. Each side wing portion advantageously extends laterally and rearwardly from the central portion of the craft, so as to define an open area therebetween, adjacent a transom of the central portion of the hull. The hull may additionally include a cover portion which covers this open area if desired, provided that the area below the cover portion is well vented.

The hull is preferably provided with two propellers attached to the transom of the central portion of the hull. The propellers are preferably of the type described and claimed in International Application No. PCT/GB/00388.

The hull may advantageously incorporate an abruptly downswept trailing edge portion. The trailing edge portion may be integrally formed in the hull or may conveniently be provided in the form of a rear flap means affixed to a trailing end of the hull, the flap means projecting generally downwardly from the hull at an angle of greater than 45 degrees, preferably at an angle of substantially 90 degrees, to the free water surface (at design conditions). Such a flap means is described

in detail in my UK application filed the same day as the present application and entitled "Hulls for Planing and Semi-planing craft", the content of which is incorporated herein by reference. The flap means preferably extends over the full width of the transom of the central portion of the hull and preferably also extends across the full length of inner and trailing edges of each side wing portion defining the open area at the rear of the hull. The chord of the flap means is preferably variable. The chord of the flap means at the transom of the central portion of the hull may advantageously be independently variable of the chord at the inner and trailing edges of the wing portions.

The central portion of the hull may include a nose portion which advantageously comprises a forward surface extending rearwardly and downwardly from a nose of the hull towards a trailing end portion of the central portion of the hull, and lightly cambered in longitudinal section thereof such that the angle of said forward surface relative to the water surface, in use of the hull, is progressively reduced along the length of said nose portion towards said trailing end portion of the hull. This feature is also described in detail in my above-mentioned UK patent application entitled "Hulls for Planing and Semi-planing Craft" already incorporated herein by reference.

Preferably, each side wing portion is lightly cambered in transverse cross-section thereof such that the angle of an underside of each side wing portion relative to the water surface is progressively reduced from a tip of the wing portion, along the transverse width of the wing portion, towards the central portion of the hull. Each side wing portion is preferably also similarly lightly cambered in longitudinal section thereof.

The cambered surfaces of the hull of the invention lead to much reduced lateral drag and thus less tendency for the hull to "dig in" while turning.

The hull may further include a fin or keel which may be formed and arranged so that the centre of lateral resistance thereof is substantially vertically aligned with the centre of gravity of the hull. The fin may be retractable to reduce drag when not required.

According to a third aspect of the invention there is provided a water craft incorporating a hull as above-described.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings in which:

FIG. 1 is a side elevation of a planing hull of known art operating at sub-planing speed;

FIG. 2 shows the hull of FIG. 1 operating at its design speed and attitude;

FIG. 3 is a plan elevation of an improved hull of known art;

FIG. 4 is a side elevation of the hull of FIG.3;

Fig. 5 is an isometric view from above of a hull according to the present invention;

FIG. 6 is a side elevation of the hull of FIG. 5;

FIG. 6A is a schematic side view of a portion of the hull of FIG. 6, showing a spray sheet created by the hull;

FIG. 7 is a plan elevation of the hull of FIGS. 5 and 6, showing lifting surfaces thereof, and with a rear flap and propellers omitted for clarity;

FIG. 8 shows the hull of FIG. 6 in plan elevation;

FIG. 9 shows the hull of FIG. 6 in rear elevation;

FIG. 10 is an isometric view of the underside of the hull of FIG.6;

FIG. 11 is a schematic side view of an embodiment of the invention incorporating a chine hull and fold-up wings;

FIG. 12(a) is a cross-sectional view of the hull of Fig.11, taken along the line BB, showing the fold-up wings in their lowered positions; and

Fig. 12(b) is a cross-sectional view of the craft of FIG. 11, taken along the line AA.

DESCRIPTION OF PRIOR ART HULL FORMS

FIG. 1 shows a hull 1 operating at a speed below the lift-off speed. (It will be appreciated that lift-off is the point in time at which a craft reaches its minimum sustained planing speed.) The free water surface 2 is distorted due to the bow-wave created by the hull. The hull has a positive angle of incidence α_1 at its entry point 3 relative to the free water surface 2. The hydrodynamic centre of lift C_p (also known as the "lift centre" or the "centre of pressure") is forward of the centre of gravity C_g and the resulting clockwise moment is balanced by arranging that the direction of the thrust T generated by the propeller 4 generates an equal anticlockwise moment about C_p. Alternatively transom flaps may be fitted to move the centre of lift C_p aft such that it is vertically aligned with the centre of gravity C_g.

FIG. 2 shows the same hull 1 operating at its design speed. The free water surface 2 is now much less distorted by the hull. The hull has a positive angle of incidence α_1 at its entry point 3 relative to the free water surface 2. The centre of lift C_p is now aft of the centre of gravity C_g and the resulting anti-clockwise moment is balanced by arranging that the direction of the thrust T generated by the propeller 4 generates an equal clockwise moment about C_p. Alternatively transom flaps may be adjusted to provide negative lift such as to move the centre of lift C_p forward such that it is vertically aligned with the centre of gravity C_g.

FIG. 3 shows a plan elevation of a hull 1 of the type proposed in US5685253, showing half the lifting surface area of the

hull at the lift-off speed and the design speed of the hull. FIG. 4 is a side elevation of these same surfaces. Suffix 1 refers to values at design speed and suffix 2 to values at planing speed (i.e. lift-off). At the design speed the hull 1 intersects the free water surface 2_1 at an angle of incidence α_{11}, the centre of lift is at C_{p1} and the water-plane area (i.e. area of the planar intersection of the undisturbed water surface with the hull) is A_1 and has a span S_1. The centre of gravity C_g is vertically aligned with the centre of lift C_{p1}. At lift-off speed the lift surface area A_2 is much greater but the span S_2 is only marginally increased. In this case the lift centre C_{p2} is significantly forward of the centre of gravity C_g so that the hull will need trimming by some means. The lift-off angle of incidence α_{12} will normally be significantly greater than the design angle of incidence α_{11} to provide an increased lift coefficient.

DETAILED DESCRIPTION OF AN EMBODIMENT ACCORDING TO THE INVENTION

FIG. 5 is an isometric view from above of a hull according to a preferred embodiment of the invention. FIG. 6 is a side elevation of the hull. As seen from FIG. 5, the hull 1 is generally delta-shaped, having a central portion 1a and two side wing portions 1b, 1c extending laterally and rearwardly from the central portion 1a. Each side wing portion 1b, 1c incorporates a trailing end portion 2b, 2c which projects rearwardly behind a transom 3 of the central portion 1a of the hull, the trailing end portions of the wing portions 1b, 1c defining an open area 5 at the rear of the hull, adjacent the transom 3 of the central portion 1a thereof. The generally delta-shape of the hull provides good aerodynamic stability by moving the aerodynamic lift centre C_a much further aft than in some known prior art. Comparing the hull of Fig.5 with the prior hull of Fig.3 it can be seen that the open area or "cut-out" 5 of the hull of the present invention is generally deeper and wider in length and width, relative to the full

length and width of the hull, than the open area provided in the prior art hull. The aerodynamic lift centre C_a is much further aft in the hull of Fig.5 than in the hull of Fig.3, as shown in the drawings. Moreover, the nose 1d of the central portion 1c of the hull of Fig.5 is much broader and blunter than the pointed V-shaped nose of the hull of Fig.3.

In the preferred embodiment shown in Fig.6, a forward portion of the underside of the central portion 1a of the hull is lightly cambered, as described in my afore-mentioned other application filed concurrently with the present application, such that the angle of said forward surface relative to the water surface, in use of the hull, is progressively reduced along the length of said nose portion towards said trailing end portion of the hull.

In this preferred embodiment, a rear flap 20 is also fixed to hull 1 so as to lie at an angle of 90 degrees to the design water plane 2_1. The flap 20 forms the transom 3 of the central portion 1a of the hull, and extends along the full length of the inner edges 6b, 6c of the two projecting portions 2b,2c of the side wing portions 1b,1c, and across the trailing edges 7b,7c thereof. Variable surface propellers 22,22a as described in PCT Application No PCT/GB99/00388 are driven by variable speed electric motors 24, 24a via reducing gearboxes 23, 23a which are bolted to the flap 20. (Other embodiments are possible which do not incorporate the flap 20 shown in Fig.5. In such cases it will be appreciated that the gearboxes 23, 23a will instead be mounted to the rear end of the central portion 1a of the hull.)

It will be appreciated that the hull is capable of providing little side thrust to balance any side force excerpted by the propeller(s) during turning of the hull and that a fin or keel 50 such as shown (in broken lines) in Fig.6 (extending downwardly from an underside of the hull) may be required to provide any such side thrust. In fact, the variable surface

drive propellers 22,22a allow turning moment to be provided by increasing the thrust of one propeller while reducing the thrust of the other and in this case very little or no side force is exerted on the hull by the propellers. The underside 50b,50c of each side wing is lightly cambered in both transverse and longitudinal cross-section thereof, so that the angle the underside of each side wing makes with the water surface is progressively reduced along the transverse and longitudinal length of the side wing, from the tip 10b,10c of each wing towards the central portion of the hull, and from the trailing edge 7b,7c of each wing towards the forward end of each wing, respectively.

FIG. 7 shows a schematic plan elevation of the underside of the hull 1, showing the lifting surfaces of the hull at the planing speed and the design speed of the hull 1. To avoid confusion, the rear flap 20 and propellers have been omitted from FIG. 7. Again, suffix 1 refers to values at design speed and suffix 2 to values at lift-off speed. As shown in Fig.6, at the design speed the hull 1 intersects the free water surface 2_1 at point 3_1 in Fig.6, at an angle α_{11}, and the hydrodynamic centre of lift C_p of the hull is approximately halfway along the chord C1 of the design lift area A_1 and is vertically aligned with the centre of gravity C_g of the hull. The aerodynamic centre of lift C_a is forward of the hydrodynamic centre of lift C_p and in fact lies above the hull 1 . The vertical position of C_a relative to the hull is shown in Fig.6. The water-plane area is A_1 and has a span S_1, at the design speed. By reference to FIG. 3 and FIG. 7 it will be evident that the aspect ratio (S^2/A) at the design speed is much greater for the hull of Fig. 7 than is the case for the prior art hull of Figs.3 and 4. Also, it will be noted that the lift area at design speed is generally in the shape of a thin rectangle, without any thin rearwardly extending leg portions like those of the design lift area in the hull of Fig.3.

At lift-off speed the hull 1 intersects the free water surface 2_2 part-way along the length of the hull at point 3_2 at an angle α_{12}. It will thus be noted that a forward portion of the hull is not in contact with the water surface at lift-off speed. The lift surface area A_2 and the span S_2 are both greater than A_1 and S_1 (the lift surface area and span respectively at design speed i.e. the speed at which the craft is designed to operate) but although the aspect ratio (S_1^2/A_1) at lift-off is lower than the aspect ratio (S_2^2/A_2) for the design conditions, it is still high compared with the aspect ratio for the prior art hull of Figs. 3 and 4. The shape of the lift-off and design lift areas A_2, A_1, as can be seen from Fig.7, are such that their centres are coincident. Thus, the lift centre C_{p2} at lift-off is coincident with the lift centre C_{p1} at design speed. It will be noted that the lift area A_2 at lift-off in the hull of Fig.7 is generally more U-shaped than V-shaped, having a thick forward portion P and two rearwardly extending leg portions Q,R. In the hull 1 of Figs. 5,6 and 7, the lift centre C_p remains vertically aligned with the centre of gravity C_g at both lift-off and design conditions. The angle of incidence α_{12} is greater than α_{11} so as to provide an increased lift coefficient but the attitude of hull 1 remains sensibly unchanged. The thrust T is virtually aligned with the centre of pressure C_p about which it provides little moment.

The transverse line 12 in Fig.7 is the forward portion of the leading edge 28 at which the water-plane meets the hull at design conditions corresponds to point 3_1 in Fig. 6. In Fig.7 this line 12 is shown perpendicular to the longitudinal axis X of the hull, but in other possible embodiments the leading edge 28 may follow some other path which is generally transverse over the majority of its length, such as the curvilinear path 12a shown in broken line in Fig. 5. From FIG. 5 it will be evident that the span S_1 of the lifting surface at the design point is large relative to the chord C1 thereof (i.e. the wetted length of the hull, in the longitudinal

direction) and that line 12 being in a generally transverse direction will cause the spray sheet 26 shown in FIG. 6A to be projected generally forwards such that the craft will ride over it. In practice, if the angle α_{11} is small the amount of spray generated is minimal but is still sufficient for entrained air generated as the hull rides over it to sensibly reduce the friction resistance. Another advantage of the high aspect ratio is that the pressure peaks generated at the leading edge of the wetted section (and also at the trailing edge of the wetted section in the preferred embodiment of the hull, described below with reference to FIG. 7) will remain sensibly at their theoretical two dimensional values over the majority of the span. Due to the presence of the portion 27 of the lift-off lift area A_2 surrounding the design lift area A_2, the tip losses resulting from the pressure reduction at the leading edge 28 of the design lift area A_1 are significantly reduced compared to those for aircraft wings of the same aspect ratio.

At lift-off speed a forward portion 11b of the leading edge 11 of the wetted section (this forward portion corresponds to point 3_2 in Fig. 6) is preferentially arranged such that it is transverse over a large proportion of the wetted span S_2 such that the craft rides over the forward-projected spray sheet as before. In this case a rear portion 11a of the leading edge 11 bends sharply aft, blending into a tip section 11c. The precise shape of line 11 may be determined to optimise the balance of the boat and to minimise the wetted area. For instance, it may sweep back at a steeper angle and then sweep out to form a winglet at the stern as shown by line 11d in Fig.7.

Longitudinal stability

By reference to FIG. 5, 6 and 7 it will be evident that if the craft pitches such that its bow 32 raises the hydrodynamic centre of lift C_p will move sharply rearwards as the stern of the craft 31 becomes immersed. The centre of gravity C_g now

being well forward of the hydrodynamic centre of lift C_p , the weight of the craft will apply a strong restoring moment to stabilize the craft. This rearward movement of the centre of lift also has the effect of reducing the pitch angle.

In the case that the bow 32 lowers, the leading edge of the wetted area 12 will move rapidly forward and, in the case where the hull 1 has a longitudinal section wherein the forward surface of the central portion 1a of the hull is of generally lightly cambered form (as afore-described), the hull will tend to roll forward such that the centre of hydrodynamic lift C_p will move rapidly forward whilst the angle of incidence α_{11} remains sensibly constant. The generally delta-shape of the hull, and high aspect ratio thereof, is designed so that the hydrodynamic centre of lift C_p may typically move from 60% of the craft length to 100% for an incidence change of 3 or 4 degrees. The accentuated movement of the hydrodynamic lift centre forwards or aft for small changes in pitch angle renders the craft extremely stable in pitch.

Aerodynamic stability

Whilst the stern cut-out (open area 5) of the hull of FIGS.5 and 6 is shown open, it may conveniently be decked over or otherwise covered in, provided that the space created remains well vented. Covering the cut-out will have the effect of moving the aerodynamic centre of lift C_a further aft. A tail fin or keel 30 may also be provided for this purpose. In the case that the hull starts to pitch such that the aerodynamic lift would be increased (e.g. in severe wind and/or wave conditions which cause the craft to adopt a high angle of attack) the centre of hydrodynamic lift C_p will move sharply rearwards as the stern 31 of the craft becomes immersed. The centre of gravity C_g now being well forward of the hydrodynamic centre of lift the weight if the craft will apply a strong restoring moment to stabilize the craft and prevent it flipping rearwards.

Turning

The fin 50 is configured such that its own centre of gravity is vertically aligned with its own hydrodynamic lift centre. The fin 50 operates at low slip angle and creates very little drag in turning maneuvers. The fin also operates at low drift angles and will only minimally influence the flow to the propellers. The fin 50 is also retractable so that it can be retracted when not required.

The position of flap 20 can be adjusted relative to hull 1 to provide a variable flap chord as provided for in my afore-mentioned other UK patent application filed on the same day as the present application. Four low pressure hydraulic actuators 21 provide differential adjustment at the front and the rear of the flap. Adjustment means (not shown) may beneficially be provided to adjust the heights of the gearboxes 23,23a relative to the flap 20.

FIG. 8 is a plan view of the embodiment of FIG.7, and FIG. 9 is a rear view of the same embodiment from which it can be seen that the two side wing portions 2b,2c are each inclined upwardly at an angle Δ to the underside 36 of the central portion 1a of the hull. The angle Δ is chosen to be in the range of typically 2 to 10 degrees. This provides a suitable span at lift-off and at the design point, as well as giving smooth entry conditions to the hull during turning maneuvres.

FIG.10 is an isometric view of the underside of the embodiment of FIG. 6 from which the fair lines and the absence of drag-producing appendages will be evident.

It should be noted that the hull width in the above-described embodiment of Fig.5 is generally greater than for known prior art hulls and allows the higher aspect ratios of the hull of the present invention to be achieved, and also increases the Froude number of the hull, as well as providing enhanced

lift/drag ratios. The wide hull also helps provide advantageous entry conditions in turning maneuvres. Typically, the hull length to hull width ratio of a hull according to the invention will lie in the range of from 1.75 for small leisure craft, up to 3.0 or more for large ships.

It will be appreciated that in the hulls according to the invention as described above, the configuration of the hull is such that lift and drag are substantially independent of craft heading ε i.e. the angle between the actual direction of travel and the longitudinal axis of the craft, as shown in Fig.8. In effect, small heading angles (of a few degrees) do change any significant change in the longitudinal section of the hull. This is largely due to the rounded and blunt-nosed shape of the nose portion of the hull which is designed so that a section through the hull at any point is very similar to the longitudinal section of the hull. The result is to provide smooth entry without creating negative values of the pressure coefficient at all forward values of the craft heading. This has the advantage of ensuring that speed is not lost in a turn.

The embodiment of the hull shown in the Figs. is generally intended for a small electrically driven hydroplaning leisure craft, although the hull of the invention is also applicable to other types of craft. Chine hulls may be blended onto the top of the hull form shown in the Figs., where higher volume is required for living accommodation, or freight storage volume, etc. Fig. 11 illustrates schematically such a hull 40 having a lower hull section 41 and a chine hull 42 blended thereto. Hulls with fold-up wings 1b,1c or foils, or with fold-up stern extensions, are also possible, in order to enable the beam or length of the hull to be reduced in order to satisfy berthing requirements, PANAMAX (permitted width for traversing the Panama canal) etc. The hull of Fig. 11 has a pair 43b,43c of such fold-up wings and a stern extension 46. Fig. 12 illustrates the craft with the wings in their lowered

positions 44b,44c. Each wing may be raised to its stowed position 45b,45c when necessary to reduce hull width and/or length.

It will further be appreciated that although the hull of the invention has been designed so that its centre of gravity C_g and centre of hydrodynamic lift C_p are substantially vertically aligned both at lift-off and design speed, in practical operation of a craft incorporating the hull small deviations from vertical alignment of C_g and C_p are tolerable, and in some cases may be unavoidable. For example, whilst part of the variable load (such as fuel tanks) of the hull may be positioned close to the centre of gravity, the rest of the variable load may be positioned elsewhere, which means that the precise position of the centre of gravity will often vary to at least some extent in practical use of the hull. Generally the flap chord, hull chord, and hull attitude (trim angle) may be varied in such cases in order to optimise the lift/drag ratio whilst maintaining the stability criteria (a "smart" controller may be provided for this purpose).

As an example of tolerated variation in the position of the centre of gravity C_g relative to C_p, for a small leisure craft we propose that variation in the position of C_g relative to C_p (horizontally) by up to approximately 3% of the craft's length (at lift-off or at design speed) will result in a variation in the hull attitude (trim angle) of approximately only 0.3 degrees.

It will further be understood that the precise relative position of the centre of lift C_p to the centre of gravity C_g will at least to some extent depend on moments due to forces including: propulsor thrust forces, inertial forces, aerodynamic lift and drag forces acting on the craft at any one time. For all but very high speed craft, or lightweight craft operating at very high angles of incidence, the aerodynamic moments acting on the craft are small. The thrust

moment is also ideally quite small and inertial moments are quite small except for lightweight craft whilst accelerating rapidly. Nevertheless, movement in the centre of pressure can in most cases be taken care of, if desired, by a small change in the hull attitude (namely the trim angle) so as to modify the shape of the lifting surface and consequently the centre of lift C_p. Where a smart controller system is provided, the adjustment may be made by altering the flap position such as to vary the lift coefficient and the centre of lift C_p. Alternatively, the adjustment may be made by a combination of these two methods.

Similarly, variation in the position of the centre of gravity can be allowed for at design speed either by allowing the craft to pitch slightly forward to move the centre hydrodynamic lift C_p forward, or to allow the craft to pitch slightly rearward to move the centre of lift aft. Alternatively, the flap chord can be slightly decreased which lowers the lift coefficient thus increasing the chord and moving the centre of lift forward, or increasing the flap chord which moves the centre of lift aft.

For any particular craft, the centre of lift at speeds below the design speed may be varied by increasing or decreasing the flap chord at the forward end of the cut-out 5 and at the rear of the craft. Increasing the flap chord increases the lift so that by increasing the flap chord for the central portion 1a and decreasing it for the wings, more lift will be generated by the forward central portion and less will be generated by the wings portions 2b,2c which are situated further aft. The effect would be to move the centre of lift forward (or to pitch the craft rearward). Increasing the flap chord for the wing portions and decreasing the flap chord for the central portion of the hull will have the opposite effect.

CLAIMS

1. A hull (1) for a water craft, wherein the centre of gravity (C_g) of the hull is substantially vertically aligned with the centre of hydrodynamic lift (C_p) of a lifting surface of the hull, both at lift-off speed and at design speed.

2. A hull according to claim 1, wherein the centre of gravity (C_g) and centre of hydrodynamic lift (C_p) are substantially vertically aligned at all hull speeds between lift-off and design speed and above.

3. A hull according to claim 1 or claim 2, wherein the centre of gravity (C_g) and centre of hydrodynamic lift are also substantially vertically aligned at hull speeds below lift-off.

4. A hull for a water craft, wherein the aspect ratio (S^2/A) of the hull (1) at design speed is in the range of 2.5 to 5.0.

5. A hull according to claim 4, wherein the aspect ratio (S^2/A) of the hull (1) at lift-off speed is in the range of 1.5 to 2.5.

6. A hull according to any preceding claim, wherein a leading edge (28) of the wetted area of the hull (1) at design speed is generally transverse to the direction of forward movement of the hull along at least a portion (12) of its length, whereby a spray sheet (26) which may be created by the hull, in use thereof, is projected generally forwards such that the craft rides over the spray sheet.

7. A hull according to claim 6, wherein the leading edge (28) of the wetted area of the hull at design speed is generally transverse to the direction of forward movement of the hull along at least a substantial portion (12) of its length.

8. A hull according to any preceding claim, wherein the hull (1) is of generally delta-shape in plan view, comprising a central portion (1a) and two side wing portions (1b, 1c).

9. A hull according to claim 8, wherein each side wing portion (1b, 1c) extends laterally and rearwardly from the central portion (1a) so as to define an open area (5) therebetween, adjacent a transom (3) of the central portion of the hull.

10. A hull according to claim 9, wherein the hull (1) additionally includes a cover portion for covering this open area.

11. A hull according to claim 9 or claim 10, wherein the hull is provided with two propellers (22, 22a) attached to the transom (3) of the central portion of the hull.

12. A hull according to any of claims 9 to 11, further including an abruptly downswept trailing edge portion.

13. A hull according to claim 12, wherein said trailing edge portion is integrally formed in the hull.

14. A hull according to claim 12, wherein said trailing edge portion is provided in the form of a rear flap means (20) affixed to a trailing end of the hull, the flap means projecting generally downwardly from the hull at an angle of greater than 45 degrees to the free water surface (2_1), at design conditions.

15. A hull according to claim 14, wherein the flap means projects generally downwardly from the hull at an angle of substantially 90 degrees.

16. A hull according to claim 14 or claim 15, wherein said flap means extends over the full width of the transom of the central portion of the hull and also extends across the full

length of inner (6b, 6c) and trailing (7b, 7c) edges of each side wing portion (1b, 1c) defining the open area (5) at the rear of the hull (1).

17. A hull according to any of claims 14 to 16, wherein the chord of the flap means is variable.

18. A hull according to claim 21, wherein the chord of the flap means at the transom (3) of the central portion (1a) of the hull is independently variable of the chord of the flap means at the inner and trailing edges of the wing portions.

19. A hull according to any of claims 8 to 18, wherein the central portion (1a) of the hull includes a nose portion (1d) which comprises a forward surface extending rearwardly and downwardly from a nose of the hull towards a trailing end portion of the central portion of the hull, and lightly cambered in longitudinal section thereof such that the angle (of said forward surface relative to the water surface, in use of the hull, is progressively reduced along the length of said nose portion towards said trailing end portion of the hull.

20. A hull according to any of claims 8 to 19, wherein each side wing portion (1b, 1c) is lightly cambered in transverse cross-section thereof such that the angle of an underside (50b, 50c) of each side wing portion relative to the water surface is progressively reduced from a tip (10b, 10c) of the wing portion, along the transverse width of the wing portion, towards the central portion (1a) of the hull (1).

21. A hull according to claim 20, wherein each side wing portion (1b, 1c) is also similarly lightly cambered in longitudinal section thereof.

22. A hull according to any of claims 8 to 21, wherein each side wing portion (1b,1c) has an underside portion which is

inclined to an underside (36) of the central portion (1a) of the hull at an angle (Δ) which is in the range of 2 to 10 degrees.

23. A hull according to any preceding claim, further including a keel (50) extending downwardly form an underside of the hull and which is formed and arranged so that the centre of lateral resistance of the keel (50) is substantially vertically aligned with the centre of gravity (C_g) of the hull.

24. A hull according to claim 23, wherein said keel (50) is retractable.

25. A water craft incorporating a hull (1) according to any preceding claim.

26. A water craft according to claim 25, wherein the hull (1) is formed and arranged such that, if the craft pitches such that the bow (32) of the craft raises, the hydrodynamic centre of lift (C_p) of a lifting surface of the hull moves sharply rearwards as the stern of the craft becomes immersed.

27. A water craft according to claim 26, wherein the hull (1) is also formed and arranged such that if the craft pitches such that the bow (32) of the craft lowers, the hydrodynamic centre of lift (C_p) of said lifting surface of the hull moves sharply forwards.

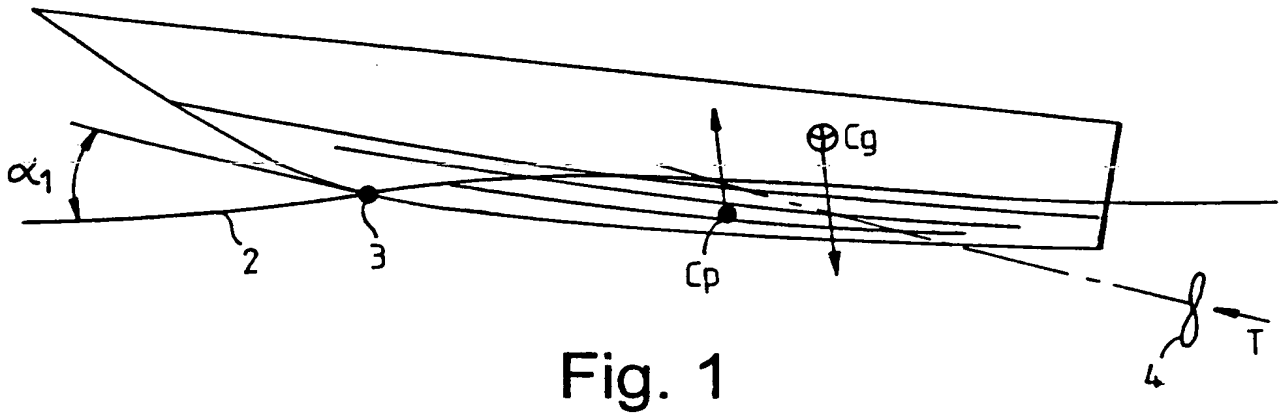

Fig. 1

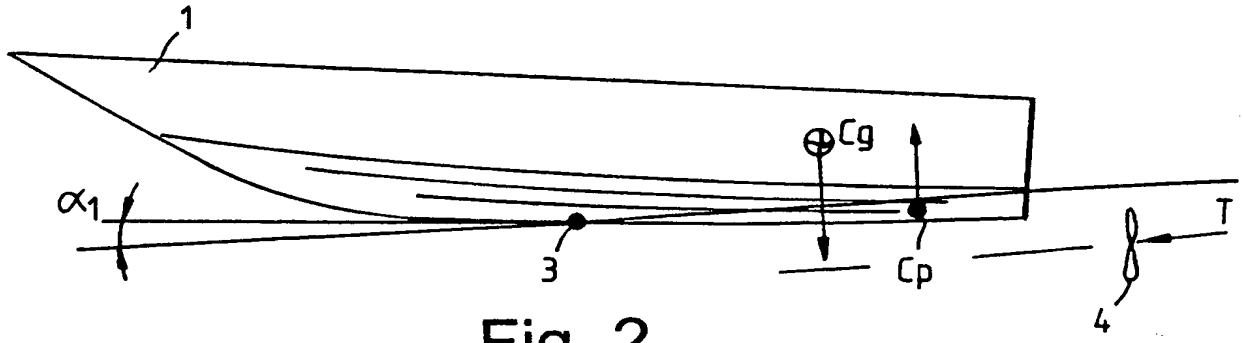

Fig. 2

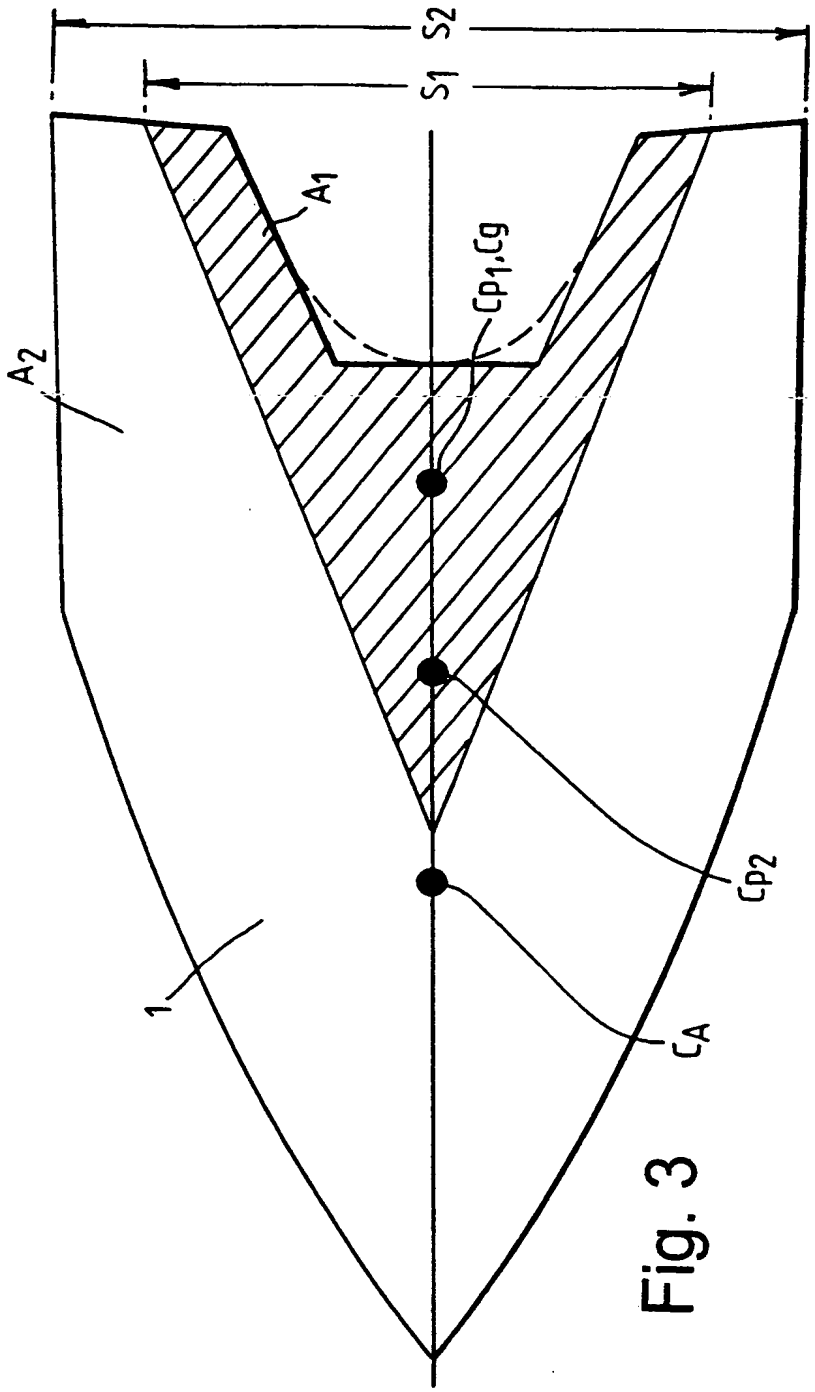

Fig. 3

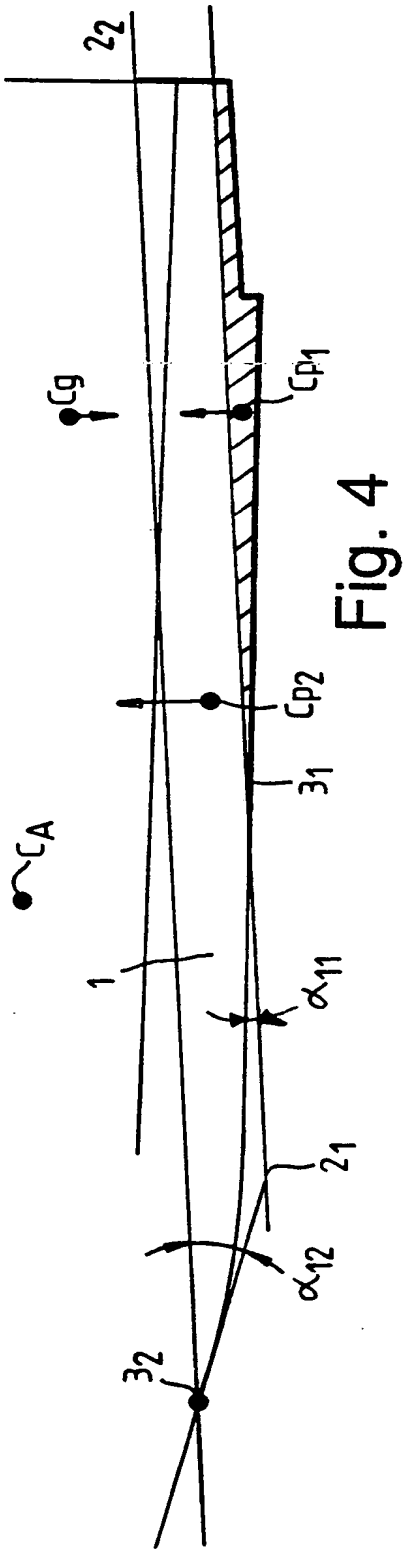

Fig. 4

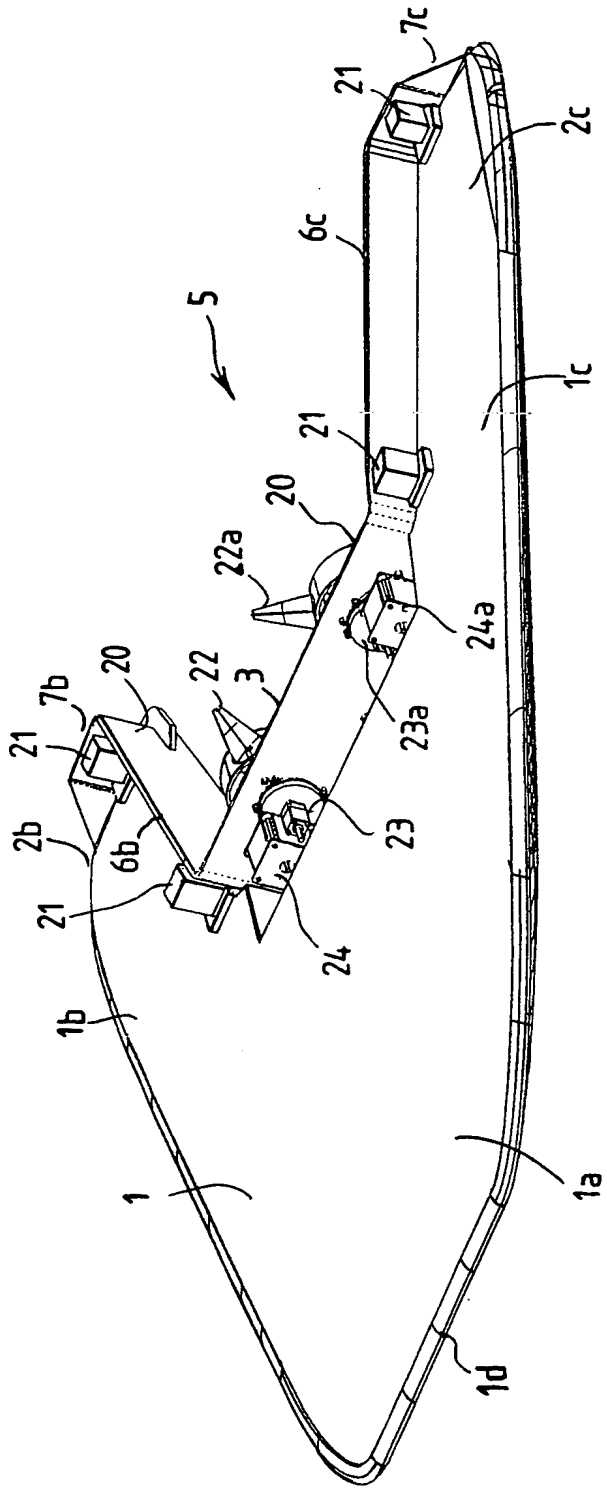
7c
21
2c
6c
5
1c
21
20
22a
24a
20
22
3
7b
21
23a
2b
6b
23
21
24
1b
1
1a
1d

Fig. 5

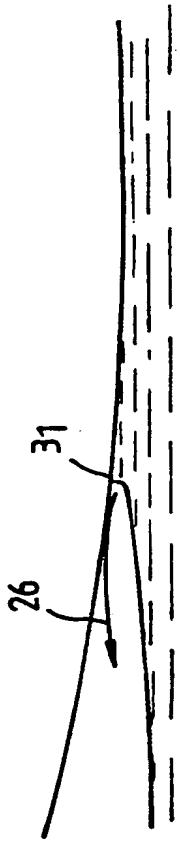

Fig. 6A

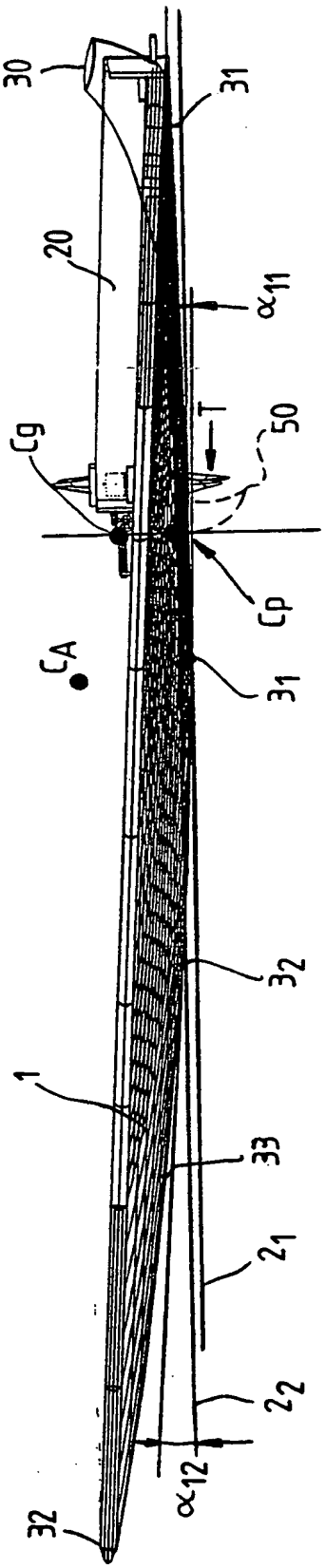

Fig. 6

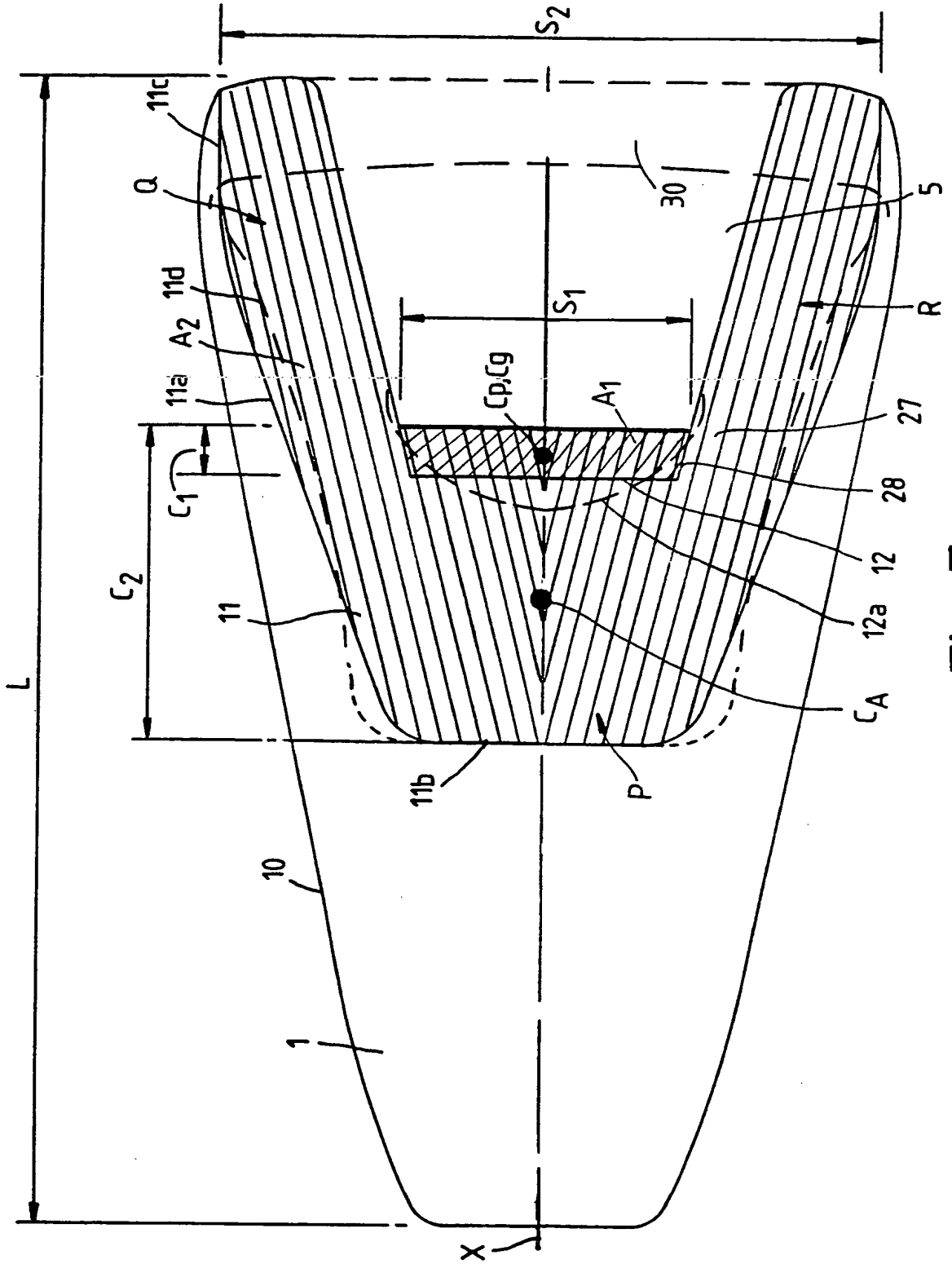
S2
11c
Q
30
5
11d
A2
S1
R
11a
Cp,Cg
A1
27
C1
28
C2
12
11
12a
L
CA
11b
P
10
1
X

Fig. 7

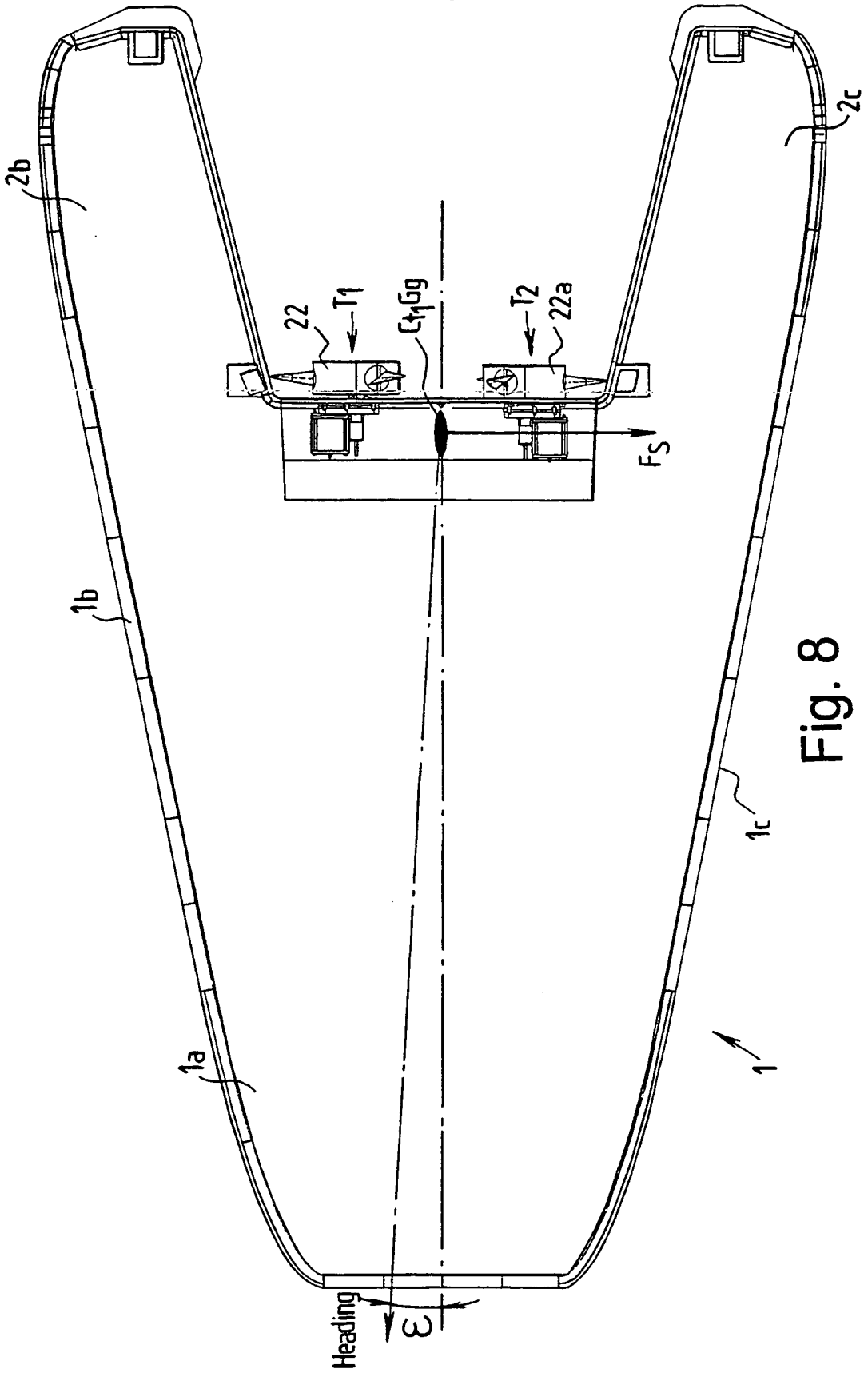

Fig. 8

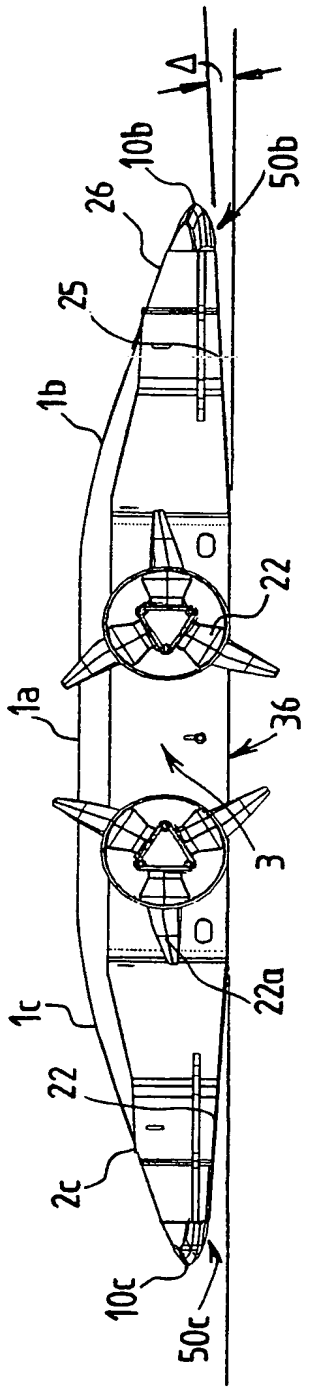

Fig. 9

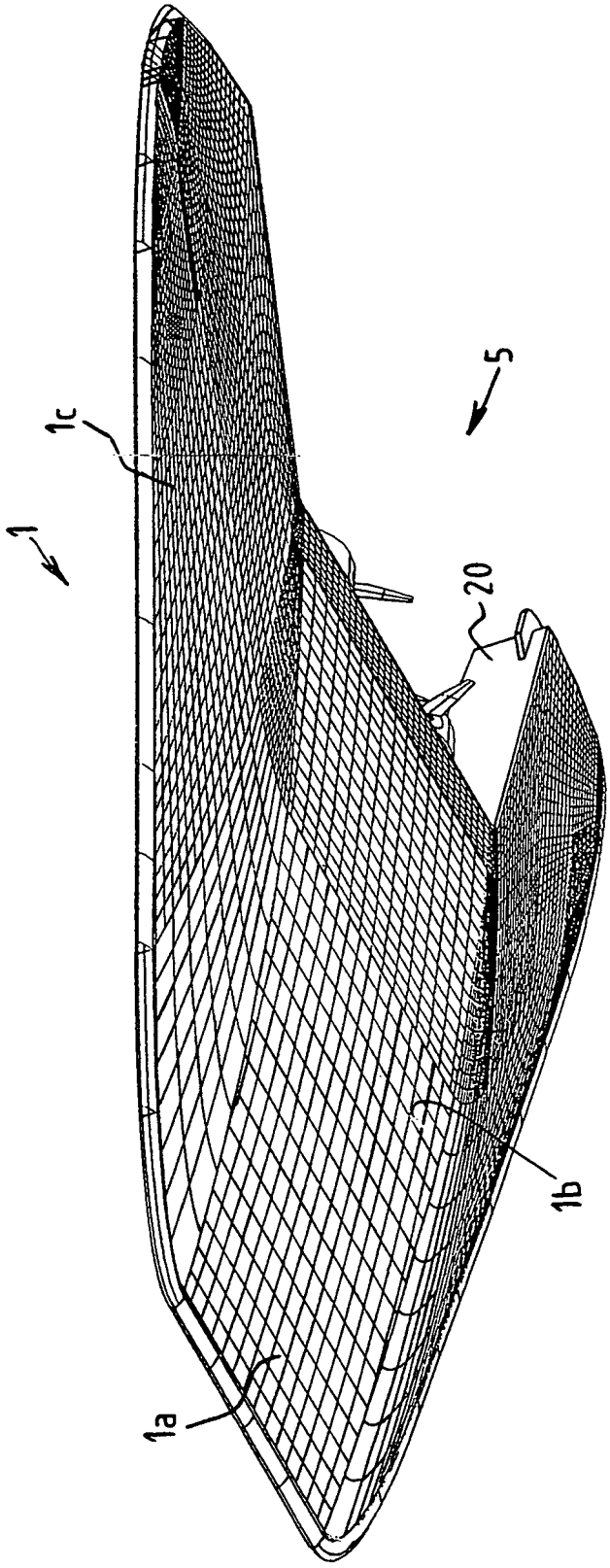

Fig. 10

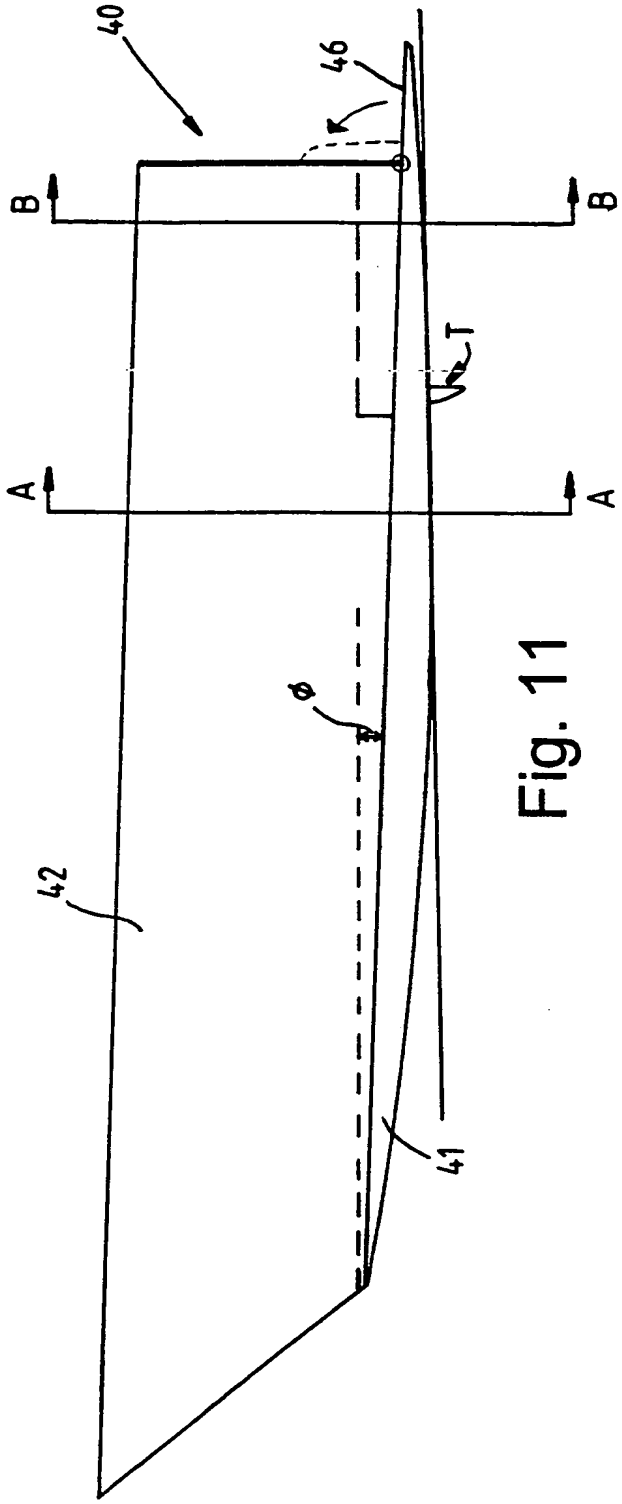

Fig. 11

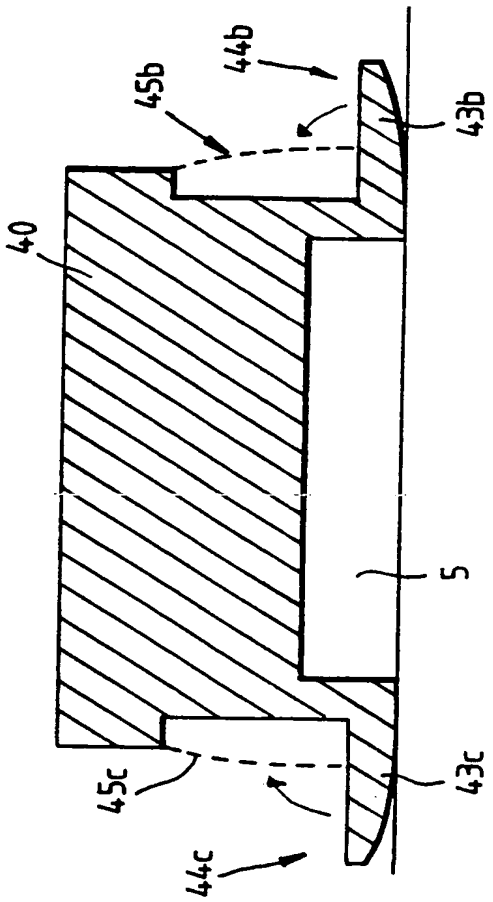

Fig. 12(b)

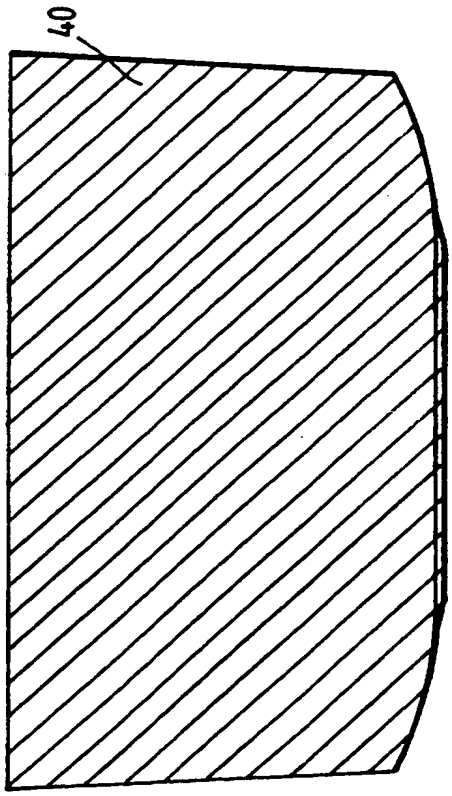

Fig. 12(a)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/00868

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B63B1/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	FR 2 650 244 A (MOULIN OLIVIER) 1 February 1991 (1991-02-01) figures column 2, line 35 -column 3, line 4 ---	1-3, 23-27 8
Y A	GB 2 262 718 A (D'ALMADA-REMEDIOS MICHAEL JOSEPH) 30 June 1993 (1993-06-30) claim 15; figure 2 page 6, line 32 -page 7, line 30 --- -/--	8 1,25

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 July 2000	09. 08. 2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Häusler, F.U.

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 774 902 A (SINCLAIR JR THOMAS L) 4 October 1988 (1988-10-04)	1-3,25
Y	abstract; claims 1,4,5; figures 1-3 column 2, line 51 -column 3, line 13 column 5, line 7 - line 17 column 6, line 9 - line 13	6
Y	EP 0 304 821 A (YAMAHA MOTOR CO LTD) 1 March 1989 (1989-03-01) figure 7	6
X	US 4 058 077 A (JOHANSSON STEN E) 15 November 1977 (1977-11-15) abstract; claim 1; figures 1,2,4 column 1, line 41 - line 64	1,2,25
X	US 3 650 239 A (GAST STEWART P) 21 March 1972 (1972-03-21)	1-3,25
A	claim 1; figures 1,2 column 4, line 63 -column 5, line 5	9,10
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A	DE 20 44 999 A (SAITO ITSUO ET AL.) 1 April 1971 (1971-04-01) claims 1,5; figures 1,3 page 3, line 30 - line 35 page 4, line 23 -page 5, line 15	4-7,25
A	US 5 452 675 A (DEVIN NEVILLE J) 26 September 1995 (1995-09-26) abstract; figures	4,5, 8-10,22, 25-27
A	US 4 509 927 A (IKEDA AKIRA) 9 April 1985 (1985-04-09) figures 5-7 column 2, line 36 -column 3, line 4	4,5, 8-10, 25-27
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2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 00/00868

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-3,6-27

1.1. Claims: 1-3,6,7,23-27
Hull for water craft with vertically aligned centres of gravity and hydrodynamic lift and with a transversely extending leading edge of the wetted area

1.2. Claims: 1,8-22
Hull for a water craft with vertically aligned centres of gravity and hydrodynamic lift and with a delta-shape in plan view

2. Claims: 4-27

Hull for a watercraft with a high aspect ratio at design speed

Please note that all inventions mentioned under item 1, although not necessarily linked by a common inventive concept, could be searched without effort justifying an additional fee.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 00/00868

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Information on patent family members

International Application No
PCT/GB 00/00868

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